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Blooming calendar and polliniferous plants in Djuanda Great Forest Park, West Java, Indonesia: Implication for beekeeping management

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Abstract. *Husodo T, Wulandari I, Syaputri Y, Kasmara H, Hermawan W, Kusmoro J, Shanida SS, Khairina F, Haydar MRA, Asyraf MN, Febrian RR. 2024. Blooming calendar and polliniferous plants in Djuanda Great Forest Park, West Java, Indonesia: Implication for beekeeping management. Biodiversitas 25: 3216-3229.* Information was unavailable regarding the types of pollinator plants and their blooming periods in Djuanda Great Forest Park, West Java, Indonesia. Information about flower blooming seasons was useful for various purposes. These findings will provide a basis for understanding the importance of *Apis cerana* Fabricius, 1793 in plant pollination and plant species resources for honey bees so that beekeeping practices can be carried out sustainably. The blossoming period of a plant is determined by its blooming period at the time of observation. The blooming period is observed every month in the second and fourth weeks for six months (December 2021-May 2022). Pollen collection was carried out in August 2021 (dry season). Pollen identification was carried out using the acetolysis method, which involves dissolving the non-pollen components of a sample to reveal the pollen grains, thereby enabling accurate identification. An overview of the observation records revealed the presence of 249 plant species from 82 families. The Asteraceae family has the most abundant species richness. Most plants were identified as pollinator plants (30.52%), nectariferous plants (10.04%), and plants that produce both (18.47%). Flowering plants of melliferous plants for honeybees are available throughout the rest of the year, especially from December to May. Therefore, to optimize honey harvesting, it is important to establish multiple colonies during periods of large honey flows. Honeybees may use alternative sugar sources beekeepers provide, such as fruit juice, during nectar scarcity. We would like to know more about the year-round bloom calendar. Sharing knowledge with farmers about the availability of melliferous plants in certain months will empower them to make decisions for sustainable beekeeping.

Keywords: *Apis cerana*, beekeeping, blooming, Djuanda, pollen

Abbreviations: GFP: Great Forest Park

INTRODUCTION

Pollination is an essential process for all spermatophyte plants with the aim of sexual reproduction, characterized by the transfer of pollen grains from the stamens (male reproductive organ) to the stigma (the receptor of the pistil/ female reproductive organ) (Fattorini and Glover 2020). Plants are immobile organisms by nature; they cannot move to find mates. Instead, they must either rely on external vectors to transfer their male gametes, housed within pollen, from one flower to another or self-pollinate, a process that carries long-term dangers of inbreeding and loss of genetic diversity. The wind, water, and animals, both vertebrates and invertebrates, are these vectors (Ollerton 2017).

According to recent estimates, 90% of 332,341 angiosperm species in the Global Biodiversity Information Facility (GBIF) taxon list are pollinated by animals (Tong et al. 2023), and their provided ecosystem service yearly worth is estimated to be between US$.230 and US$.410 billion (Millard et al. 2020). Animal pollinators are found in diverse groups, including bats, birds, and insects (Millard et al. 2020). The pollination of approximately 73% of the world's cultivated crops was dependent upon insects, out of which 56% come from bees, 17% from flies, 6.5% from bats, 5% from wasps, 5% from beetles, 4% from birds, and 4% from butterflies and moths (Bashir et al. 2019). Honey bees provide a wide range of pollination services to cultivated and natural landscapes (Theisen-Jones and Bienefeld 2016), making them the primary pollinators (Deuri et al. 2018).

Apis cerana Fabricius, 1793, which is known as an important native pollinator in Asia, also plays the essential role of bee product producers, such as honey and beeswax. Therefore, to promote the economic value of this Eastern honey bee, beekeeping has been practiced in each Asian country (Dar et al. 2019). The most frequently mentioned advantage of *A. cerana* is its ability to forage, even in extreme conditions. This honey bee can be cultivated without supplements if the plants are available year-round as food resources (Theisen-Jones and Bienefeld 2016).

Honey beekeeping has been practiced in Djuanda Great Forest Park (GFP), West Java, Indonesia for years. This park is located on the border of three regions, namely Bandung City, Bandung District, and West Bandung District. The GFP is one of the plant conservation sites established in Indonesia, comprising three main zones: protection, collection, and utilization. Tourism facilities can be established in the utilization zone, and the government encourages business by involving the public. The GFP has a honey bee cultivator group that uses a portion of the land and the resources within to cultivate *A. cerana* honey bees (Febrian 2022).

Regarding the mutual benefit between flowering plants and honey bees, cross-pollination by honey bees is essential for increasing quality through a more uniform ripening phase and earlier harvesting time, mainly for crops. Honey bee pollination enhances agricultural crop production and boosts honey productivity from the hive since honey bees acquire more nectar and pollen when pollinating flowering plants (Fikadu 2019). On the other hand, flowering plants provide nectar and pollen that contain carbohydrates and protein as food sources for honey bees (Bankova et al. 2018) and also provide non-nutritive benefits, including nesting materials such as waxes (Balamurali et al. 2015). Nectar secretion quality, quantity, and the optimum temperature for peak nectar secretion influenced honey productivity (Adgaba et al. 2016). The availability of fresh and nutritious pollen foraged by honey bees also mediates the colony's growth, productivity rate, and resistance to parasites, pathogens, and other factors that impact the stress level (Wood et al. 2018).

So far, no information is available regarding flowering plants and the blooming period of Djuanda GFP. According to Eleuterius and Caldwell (1984), information on flowering and fruiting seasons is used for various purposes, for example, to find out the peak flowering and fruiting seasons, when flowers bloom, fruit formation, or pollinators for each type of plant. To maximize the health and production of *A. cerana* within the GFP, a better understanding of the plant's flowering period as a food source for honey bees is needed. This will be achieved through a comprehensive study involving field observations, data collection, and analysis. These findings will be the basis for understanding the importance of plant species for honeybees so that beekeeping practices can be carried out sustainably in Djuanda GFP.

MATERIALS AND METHODS

Study area

The study occurred in three *A. cerana* beekeeping sites within the Ir. H. Djuanda Great Forest Park (Djuanda GFP), West Java, Indonesia, i.e.: Batu Garok (Bandung District), Kandang Rusa (West Bandung District), and Maribaya (West Bandung District). Pollen trapping was collected in August 2021 (dry season). Meanwhile, the blooming period of flowering plants was recorded from December 2021 until May 2022. The areas of study were grouped into four categories of land cover: forest, settlement, field, and shrubland. Beekeeping activities must be concentrated on sites that generate a large amount of nectar, pollen, and water (Hikmah et al. 2021). Thus, it is assumed that the three locations mentioned above are places for honeybees to feed because they contain various flowering plants. Therefore, we limited the research area to 1 km from each honey bee farming location in this study. Recording of flowering plants in overlapping areas (Batu Garok-Kandang Rusa and Kandang Rusa-Maribaya) was also conducted. See Figure 1 for more information.

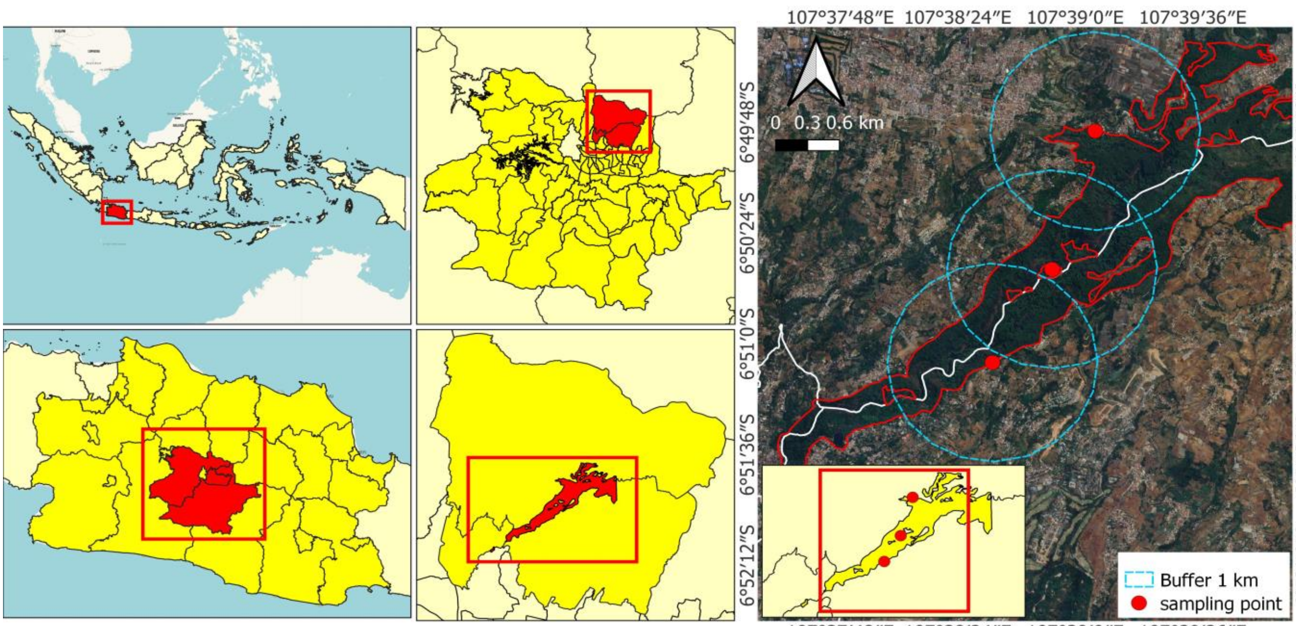

Figure 1. Study area in the Ir. H. Djuanda Great Forest Park (Djuanda GFP), Bandung City, West Java, Indonesia

Procedures

Survey of the blooming period

This study observed the species of flowering plants in Djuanda GFP. The blooming period was determined by the plants blossoming at the observation time (Jasmi 2017). A plant is said to be flowering if, at the time of observation, it is known to have flowers, either in the form of flower buds, blooming flowers, or flowers that have just passed their blooming period. The parameters observed include habitus, blooming period of the year, vegetation type, availability of pollen and/or nectar, location, and the conservation status of species by IUCN. Apart from that, the environmental parameters documented in this study were humidity, wind speed, and air temperature.

The parameters mentioned above were chosen due to the influence of plant habitus on growth and blooming times, as some plants exhibit shorter durations for these phases (Kiffle et al. 2014). Recording the blooming period was deemed necessary, given that the study aimed to construct a blooming calendar for honey beekeepers. The availability of pollen and/or nectar was considered essential, owing to the dependency of honey bee colonies on these plant features for survival (Bankova et al. 2018); the suitability of the sampled study areas for beekeeping necessitated recording the location. The conservation status of plants indicates the group's existence and the likelihood of its extinction shortly to enable sustainable use of plant material by current and future generations (Breman et al. 2021).

The blooming period observations were carried out every month from December 2021 until May 2022 in the second and fourth weeks from 7:00 a.m. to 5:00 p.m. (Handayani 2016). According to Jasmi (2017), observation was done visually, with binoculars and a prosumer camera to observe the relatively high plants. The flowering plants were collected, documented, and stored in a plastic bag. To study honey bee foraging, we observed each apiary within a 1 km radius from 7:00 a.m. to 10:00 a.m. and from 2:00 p.m. to 5:00 p.m. Honey bees may forage beyond the estimated radius. Pollen carried by bees is detected by the visibility of pollen collected on their corbicula; when collecting nectar, bees hook their proboscis at the base of the flower.

Pollen trapping

Pollen trapping was conducted in August 2021 (dry season). Different data collection periods between flowering and pollen trapping aimed to identify more plant species in the two seasons. The *A. cerana* honey beekeeping sites were in Djuanda Great Forest Park. Pollen trapping was conducted to determine the plants used as food for *A. cerana* in a landscape. According to Topitzhofer et al. (2021), this method can be used to describe plants utilized by honey bees in the landscape as a first step to determine the quantity, quality, and taxa of flowering plant species.

Pollen traps are designed to release corbicular pollen from the legs of honey bees that have returned from foraging and re-entered the hive (Judd et al. 2020). This method is more efficient if many samples were collected by trapping pollen pellets from honey bees at the entrance to the hive (Topitzhofer et al. 2021). Previous studies revealed that pollen traps stimulate honeybees to collect more, increasing pollination efficiency in crops and vegetation (Gemeda et al. 2018).

The number of samples used in this study refers to Dimou et al. (2006), who determined the diversity and abundance of pollen species at the landscape level. Pollen collection was conducted for three days (72 hours) every nine days per colony. Pollen trap installation and sampling refers to Topitzhofer et al. (2021). Colonies for pollen trapping were selected based on the high number of foragers per two minutes. The counts were conducted from 7:00 to 10:00 a.m. and 2:00 to 4:00 p.m., effective bee pollination times (Stabentheiner and Kovac 2016). The hives have wooden fittings in good condition, preferably without additional entrances and curved lids. We used nests with few alternative entrances, as this increases the likelihood of foragers reorienting themselves to the trap entrance. After fulfilling the requirements, three colonies in each sublocation were selected to install pollen traps. Installation is carried out when honey bee activity is quiet in the afternoon. All possible entrance holes into the colony were sealed with adhesive tape (Topitzhofer et al. 2021). The pollen trap was set up for 24 hours for habituation and conducted before foraging. Intensively, pollen trapping was conducted for 72 hours.

The corbicular pollen was removed from the collection container, placed in a plastic bag (Ziplock), and stored in the toolbox to avoid damage and breakage. The pollen was cleaned of attached bee parts or nest debris. To avoid contamination, we used disposable gloves when handling pollen and new gloves with each sample. We also used separate equipment to remove pollen fragments collected in each trap; each sample was recorded with the date, colony location, and sampling time.

Acetolysis method

Pollen identification is more accurate when using the acetolysis method (Jones 2014). The acetolysis method is the standard method in palynological preparation. This method is also indispensable for illustrating pollen grains by light microscopy. Stained pollen grains cover the visuals of the pollen grains, making it difficult to provide an overview of the pollen grains. The acetolysis process removes the cellular wall and the intine and destroys the aperture membrane. In addition, cleaning the surface of the pollen grain and coloring the pollen can make it easier for researchers to observe all the details of the pollen grain wall (Erdtman 1960). The Acetolysis method combines chlorination and acetylation procedures (Hesse et al. 2009).

Chlorination stage. Pollen was put into a centrifugation tube, added with 98% Glacial Acetic Acid (AAG), and 3-4 drops of HCl. Then, stir using a glass rod to mix evenly. The pollen was heated using a water bath for three minutes. After heating, the pollen was centrifuged at 2,000-3,000 rpm for 10 minutes. The supernatant was removed gently so the pollen deposits were not wasted, and the residue was washed with distilled water. It was centrifuged again at 2,000-3,000 rpm for two minutes. Washing was carried out three times to remove AAG.

Acetylation Stage. A mixture of 98% AAG and sulfuric acid in a ratio of 9:1 was dropped in the tube. After that, it was heated to 100°C for four minutes. The pollen was centrifuged at 2,000-3,000 rpm for 10 minutes. The supernatant was removed slowly so the pollen deposits were not wasted, and the residue was washed with distilled water. It was centrifuged again at 2,000-3,000 rpm for two minutes. Washing was done thrice to remove the mixture of AAG and sulfuric acid.

After the acetolysis method, the pollen samples were stored in wet preservation. The samples were stored in a 20-cc vial and added to distilled water. Halbritter et al. (2018) states that dry and fresh pollen must be hydrated with water to obtain a good-quality pollen grain. This condition ensures that the pollen grains are not damaged or contaminated with fungi. Each vial was labeled.

Then, the sample was stored in the refrigerator. A wet preservation sample is taken to observe and identify pollen, then 1-2 drops are taken on a glass object and one drop of glycerin. Halbritter et al. (2018) stated it should be observed as soon as possible after being given glycerin because the pollen grains will expand within a few days or weeks. Then, the sample was covered with a cover glass. Nail polish was applied to the edges of the cover glass to avoid shifting the cover glass. After that, the microscope slide was dried on a hotplate and labeled.

Data analysis

Plant identification

The flowering plants that had been collected and documented were then identified. This study carried out plant identification without a physical herbarium but by analyzing plant images stored on the GBIF website. Once different plant types were identified, the type of floral resources each species provides to honey bees was examined, utilizing both literature reviews from global publications on the topic and primary studies, such as pollen analysis. These methods gathered information on which plants flower without benefitting honey bees and which flowering plants benefit honey bees.

Preparation of blooming calendar

During the survey, a complete chronological record was maintained based on the flowering periods of the identified plants, and a blooming calendar was prepared accordingly. Entries were made for specific plants in the months corresponding to their blooming period (Pande and Ramkrushna 2018). Next, a bloom graph was developed, which includes two graphs depicting the bloom period: one graph shows the total calendar of flowering plants at the sample study sites without considering the provision of floral resources. The other graph compares the calendar of plants providing floral resources, including pollen and nectar for honey bees (melliferous plants).

Percent abundance of species flowering

The monthly percentage abundance of flowering plants in total and melliferous plants was calculated by pooling all the data and expressing it as a percentage using the following formula (Pande and Ramkrushna 2018):

$$\text{Percent abundance of flowering plants for a month} = \frac{\text{Number of species in a particular month}}{\text{Total number of flowering plants}} \times 100$$

Percent abundance of melliferous plants was also calculated.

$$\text{Percent abundance of melliferous plants for a month} = \frac{\text{Number of melliferous plant species in a particular month}}{\text{Total number of melliferous plants}} \times 100$$

The blooming period data that has been obtained was explained qualitatively. Plants were classified according to when they bloom, with Perennial Plants (PP) appearing at all times of the year, Biennial Plants (BP) appearing at two growing seasons of the year, and Annual Plants (AP) appearing only once during planting (Jasmi 2017). Furthermore, the flowering intensity describes the blooming period during a given time. The flowering intensity was classified into four categories: very low (SR) = the number of flowering plants observed in one month is <25%; low (R) = the number of flowering plants observed in one month is 25%-50%; medium (S) = the number of flowering plants observed in one month is 50%-75%; and high (T) = the number of flowering plants observed in one month is more than 75% (Handayani 2016).

Identification of polliniferous plants

The primary data obtained from pollen trapping was explained qualitatively. Several guidelines for identifying pollen were used, such as Erdtman (1969) and Faegri and Iversen (1989). The parameters for identifying pollen were family, species, and pollen form (pollen unit, pollen size category, pollen size (μm), and ornamentation type). Pollen measurement was carried out based on the size of the longest axis, which was divided into six sizes, namely very small: <10 μm, small: 10-25 μm, medium: 25-50 μm, large: 50-100 μm, very large: 100-200 μm, and giant: >200 μm (Erdtman 1952).

RESULTS AND DISCUSSION

There were up to 249 plant species, including 145 species in the forest type, 101 in the habitation area (settlement), 33 in the field, and 52 in the shrubland. Meanwhile, based on the sublocation of the study site, as many as 167 plant species were found within Batu Garok, 111 within Kandang Rusa, and 159 within Maribaya. The number of species in the two overlapping zones between Batu Garok-Kandang Rusa and Kandang Rusa-Maribaya was also documented. Batu Garok-Kandang Rusa had up to 83 species, whereas Kandang Rusa-Maribaya contained 74 species.

Identification of flowering plants

The overall picture of recorded observations in six months from December 2021 until May 2022 revealed the existence of 249 plant species from 82 families, which were blooming extensively scattered across the study site. Seven of the 82 families of flowering plants discovered in the observation site dominated the plant population based on the species richness. The Asteraceae family had the most abundant species richness at the study site, with 25 species, followed by the Fabaceae family with 19 species, Euphorbiaceae with 14 species, Solanaceae with 13 species, Acanthaceae with 11 species, Apocynaceae and Lamiaceae each with 10. In contrast, the other remaining families had less than ten species. Furthermore, out of 249 flowering plant species observed, 106 were herbaceous (42.57%), 68 were trees (27.31%), 62 were shrubs (24.90%), and 13 were vines (5.22%). In terms of plants life cycle, these plants were dominated by perennial plants with 217 species (87.15%), followed by annual plants with 29 species (11.65%), and biennial plants with 3 species (1.20%) (Table 1).

Potential honey bee plants

As shown in Table 1, as many as 147 species (59.04%) of the total plants identified in Djuanda GFP were potential melliferous plants. Most plants were polliniferous, with 77 species (30.92%); nectariferous, with 24 species (9.64%), and the plants that produced both were as many as 46 species (18.47%). Of the 147 potential plants, 41 species (16.47%) were proven to be polliniferous plants based on the primary studies conducted through the acetolysis method for pollen identification.

Observation of the blooming period

Throughout the study period from December 2021 to May 2022, all observed flowering plants were recorded, totaling 249 species, without consideration of their utility to honey bees. A literature review and pollen trapping results revealed that only about half of the identified species benefited honey bees. Therefore, two flowering calendars are being presented in this paper: one showing the calendar of total flowering plants without regard to their provision of floral resources, and another displaying the calendar of plants that offered floral resources such as pollen and/or nectar for honey bees (melliferous plants).

In total, the number of species flowering increased from December 2021 (82.13%) to January 2022 (86.55%) and reached its peak in February 2022 (87.95%). Then, it went lower in March 2022 (84.54%), became the lowest in April 2022 (76.31%), and increased again in May 2022. The blooming period pattern for melliferous plants was the same as the blooming period pattern for plants in total; the only difference was that the percentage of plants used by honey bees was lower than the total species in the sampled study sites. In December 2021, 49% of melliferous plants were blooming, which grew to 52.81% in January 2022, 53.41% in February 2022, and 51.41% in March 2022 before dropping to 46.99% in April 2022 and 47.59% in May 2022. The comparison chart between the calendar of flowering plants in total and the calendar of melliferous plants for honey bees can be seen in Figure 2.

Polliniferous plants

As previously stated, a primary study was conducted to identify the polliniferous plants within the sampled study sites based on pollen-trapping results obtained from bee corbicula. The food supply plants for *A. cerana* in Djuanda GFP included 41 species from 27 families. Fabaceae had the most species (four), followed by Asteraceae, Malvaceae, Myrtaceae, and Solanaceae, with three species in each family. Meanwhile, the remaining families had only one or two plant species. Out of the 41 types of pollen that were identified, 38 of them had monad pollen units, two other pollen types were polyads, and one was a tetrad. Meanwhile, based on the size category, there is one very small-sized pollen, 11 small-sized pollen, 15 medium-sized pollen, 13 large-sized pollen, and one very large-sized pollen (Table 2).

Discussion

A list (Table 1) of candidate honey bee plants and their potential uses for honey bee colonies as a source of pollen, nectar, or both is essential to assist beekeepers and researchers. This list might support a better understanding of the suitable flora for honey bees. Identifying honey bee plants can assist beekeepers in identifying ideal apiary sites and cultivating appropriate plants for their colonies. This list can also help researchers conduct melissopalynological investigations (Abouu-Shaara 2015). In addition, the list with the blooming period of six months from December 2021 until May 2022 was also created since the blooming calendar is an essential tool for deciding when to provide or cut off additional feed and the timing of honeybee colony migration (Komasilova et al. 2023). These findings might be crucial for beekeeping in maintaining profitable honeybee businesses.

According to our data, Asteraceae was the dominant family comprising flowering plants in the three sampled study sites based on species richness. This observation result is reasonable, given that the Asteraceae family is spread over all continents except Antarctica. These plants constitute the world's largest family of flowering plants, with over 1,600 genera and 23,000 species (Fu et al. 2016). The dominance of Asteraceae might also provide honey bees opportunities to forage. This situation followed a study in Africa that proved the family Asteraceae has the highest frequency occurrence as forage sources for honey bees with a percentage value of 23.81% (Larinde et al. 2014).

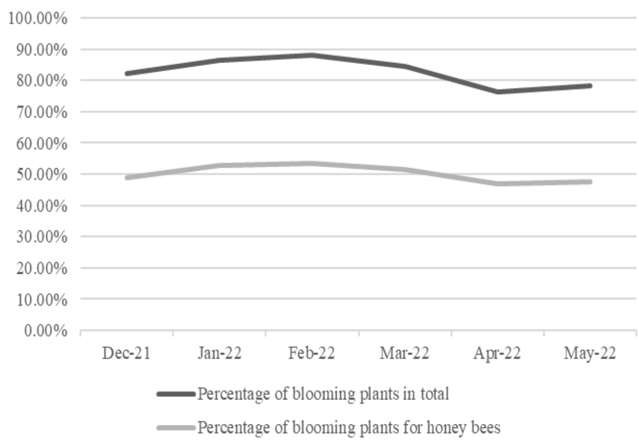

Figure 2. Blooming calendar chart comparison between plants in total and melliferous plants in Ir. H. Djuanda GFP, West Java, Indonesia

Table 1. List of flowering plants in Ir. H. Djuanda GFP, Indonesia, their habitus, life cycle, blooming period, and resources offered to honey bees

Species	Habit	LC	Blooming period	RO	RO Reference
Acanthaceae					
Asystasia gangetica (L.) T.Anderson	Hr	PP	Dec-May	N/P	Akunne et al. (2016)
Hypoestes phyllostachya Baker	Sh	PP	Mar-May	P	Suhri et al. (2020)
Megaskepasma erythrochlamys Lindau	Sh	PP	Dec-May	-	-
Odontonema tubaeforme (Bertol.) Kuntze	Sh	AP	Dec-May	-	-
Pachystachys lutea Nees.	Sh	PP	Dec-May	N	Peniwidiyanti et al. (2020
Pseuderanthemum reticulatum (hort. ex Hook.fil.) Radlk.	Sh	PP	Dec-May	-	-
Ruellia simplex C. Wright	Hr	PP	Dec-May	N	Kamaruddin and Zalipah (2020
Thunbergia alata Bojer ex Sims	Hr	PP	Dec-May	N/P	Quijano-Abril et al. (2021)
Thunbergia erecta (Benth.) T.Anderson	Sh	PP	Dec-Mar	N	Da Silva et al. (2020)
Thunbergia grandiflora (Roxb. ex Rottl.) Roxb.	Vn	PP	Dec-May	P	Jongjitvimol and Poolprasert (2014)
Sanchezia oblonga Ruiz & Pav.	Sh	PP	Dec-May	-	-
Achariaceae					
Pangium edule Reinw.	Tr	PP	Mar-May	-	-
Actinidiaceae					
Saurauia pendula Blume.	Tr	PP	Dec-May	-	-
Amaranthaceae					
Alternanthera brasiliana (L.) Kuntze	Hr	PP	Feb-May	N	dos Reis et al. (2023)
Alternanthera sessilis (L.) R.Br. ex DC.	Hr	PP	Dec-May	P	Primary data
Amaranthus spinosus L.	Hr	AP	Dec-May	P	Primary data
Celosia argentea L.	Hr	AP	Dec-May	P	Aung et al. (2018)
Gomphrena celosioides Mart.	Hr	BP	Dec-May	P	Sopaladawan et al. (2019)
Plectranthus scutellarioides (L.) R.Br.	Hr	PP	Dec-May	N	Thokchom et al. (2023)
Amaryllidaceae					
Agapanthus praecox Willd.	Hr	PP	Dec-Mar	-	-
Anacardiaceae					
Mangifera indica L.	Tr	PP	Jan-Mar	P	Primary data
Annonaceae					
Annona muricata L.	Tr	PP	Dec-May	-	-
Apiaceae					
Eryngium foetidum L.	Hr	BP	Dec-May	N/P	Silveira-Júnior et al. (2022)
Apocynaceae					
Allamanda cathartica L.	Sh	PP	Dec-May	N	Uffia et al. (2019)
Alstonia scholaris (L.) R.Br.	Tr	PP	Dec-May	P	Primary data
Asclepias curassavica L.	Hr	PP	Dec-May	N	Warren et al. (2020)
Catharanthus roseus (L.) G.Don.	Sh	PP	Dec-May	P	Sopaladawan et al. (2019)
Cerbera manghas L.	Tr	PP	Dec-May	-	-
Chonemorpha fragrans (Moon) Alston	Vn	PP	Dec-Mar	-	-
Gomphocarpus physocarpus E.Mey.	Sh	PP	Dec-May	N	Burger et al. (2024)
Nerium oleander L.	Hr	PP	Dec-May	N/P	Taha et al. (2019)
Plumeria pudica Jacq.	Tr	PP	Dec-May	-	-
Plumeria rubra L.	Tr	PP	Dec-May	-	-
Araceae					
Anthurium sp.	Hr	PP	Dec-Feb	-	-
Spathiphyllum wallisii Regel	Hr	PP	Dec-May	P	Radaeski and Bauermann (2021)
Araliaceae					
Schefflera aromatica (Blume) Harms	Tr	PP	Dec-Mar	-	-
Arecaceae					
Areca catechu L.	Tr	PP	May	P	Thokchom et al. (2023)
Arenga pinnata (Wurmb) Merr.	Tr	PP	Dec-Mar	P	Primary data
Asparagaceae					
Dracaena fragrans (L.) Ker. Gawl	Tr	PP	Mar-May	N	Abouu-Shaara (2015)
Ophiopogon japonicus (Thunb.) Ker Gawl.	Hr	PP	Dec-Mar	-	-
Yucca aloifolia L.	Sh	PP	Dec-Mar	-	-
Asphodelaceae					
Aloe arborescens Mill.	Hr	PP	Mar-May	-	-
Asteraceae					
Acmella paniculata (Wall. ex DC.) R.K.Jansen	Hr	PP	Dec-May	-	-
Ageratum conyzoides (L.) L.	Hr	AP	Dec-May	P	Primary data
Bidens pilosa L.	Hr	AP	Dec-May	P	Primary data
Coreopsis lanceolata L.	Hr	PP	Dec-May	-	-
Chromolaena odorata (L.) R.M.King & H.Rob.	Sh	PP	Dec-May	N/P	Akunne et al. (2016)
Cyanthillium cinereum (L.) H.Rob.	Hr	PP	Dec-May	P	Prajapati and Punjani (2024)

Crassocephalum crepidioides (Benth.) S.Moore	Sh	AP	Dec-May	P	Gunapala et al. (2021)
Dahlia imperialis Roezl	Hr	PP	Dec-May	N/P	Thokchom et al. (2023)
Dahlia pinnata Cav.	Hr	PP	Dec-Jan	N/P	Thokchom et al. (2023)
Dichrocephala integrifolia (Lf) Kuntz.	Hr	AP	Dec-May	-	-
Emilia sonchifolia (L.) Dc. ex DC.	Hr	AP	Dec-May	P	Puentes et al. (2019)
Erigeron sumatrensis Retz.	Hr	AP	Dec-May	-	-
Eupatorium riparium Sch.Bip. ex Schnittsp.	Hr	PP	Mar-May	-	-
Galinsoga parviflora Cav.	Hr	PP	Dec-May	P	Do Nascimento et al. (2014)
Helianthus annuus L.	Hr	AP	Dec-May	N/P	Thokchom et al. (2023)
Mikania micrantha Kunth	Vn	PP	Dec-May	P	Gunapala et al. (2021)
Montanoa grandiflora Alaman ex DC	Tr	PP	Feb-May	-	-
Sphagneticola trilobata (L.) Pruski	Hr	PP	Dec-May	P	Gunapala et al. (2021)
Synedrella nodiflora (L.) Gaertn.	Hr	PP	Dec-May	P	Nguemo et al. (2016)
Tagetes erecta L.	Sh	AP	Dec-May	N/P	Sopaladawan et al. (2019); Thokchom et al. (2023)
Taraxacum officinale (L.) Weber ex F.H.Wigg.	Hr	PP	Dec-Feb	N/P	Begum et al. (2021)
Tithonia diversifolia (Hemsl.) A.Gray	Sh	PP	Dec-May	P	Primary data
Vittadinia triloba (Gaudich.) DC.	Hr	PP	Dec-Mar	-	-
Youngia japonica (L.) DC.	Hr	PP	Dec-May	-	-
Zinnia elegans L.	Hr	AP	Dec-May	N/P	Thokchom et al. (2023)
Balsaminaceae					
Impatiens balsamina L.	Hr	AP	Dec-May	N	Thokchom et al. (2023)
Impatiens walleriana Hook.f.	Hr	PP	Dec-May	-	-
Begoniaceae					
Begonia cucullata Willd.	Hr	PP	Dec-Mar	P	Da Silva et al. (2020)
Bignoniaceae					
Bignonia callistegioides Cham.	Vn	PP	Dec-May	-	-
Handroanthus chrysotrichus (Mart. ex DC.) Mattos	Tr	PP	Dec-Mar	-	-
Jacaranda mimosifolia D.Don	Tr	PP	Dec-Mar	N/P	Thokchom et al. (2023)
Kigelia africana (Lam.) Benth.	Tr	PP	Dec-May	P	Primary data
Pyrostegia venusta (Ker Gawl.) Miers	Vn	PP	Dec-May	N/P	Polatto and Alves-Junior (2022)
Spathodea campanulata P.Beauv	Tr	PP	Dec-May	P	Primary data
Tecoma stans (L.) Juss. ex Kunth	Sh	PP	Dec-May	N/P	Taha et al. (2019)
Bixaceae					
Cochlospermum regium (Schrank) Pilg.	Tr	PP	Dec-May	-	-
Brassicaceae					
Brassica oleracea L.	Hr	BP	Dec-Jan	P	Primary data
Rorippa indica L.	Hr	PP	Dec-May	-	-
Cactaceae					
Hylocereus lemairei (Hook.) Britton & Rose	Sh	PP	Feb	-	-
Campanulaceae					
Hippobroma longiflora (L.) G.Don	Hr	AP	Dec-May	-	-
Cannabaceae					
Trema orientalis (L.) Blume	Tr	PP	Dec-May	P	Primary data
Cannaceae					
Canna indica L.	Hr	PP	Dec-May	N/P	Srivastava and Kumar (2016)
Caricaceae					
Carica papaya L.	Tr	PP	Dec-May	N/P	Akunne et al. (2016)
Chloranthaceae					
Chloranthus elatior Link	Hr	PP	Dec-May	-	-
Cleomaceae					
Cleome rutidosperma DC.	Hr	AP	Dec-May	-	-
Cleome spinosa Jacq.	Hr	AP	Dec-May	N	Raju and Rani (2016)
Combretaceae					
Terminalia catappa L.	Tr	PP	Dec-May	-	-
Commelinaceae					
Commelina benghalensis L.	Hr	PP	Dec-May	N	Akunne et al. (2016)
Commelina communis L.	Hr	PP	Dec-May	-	-
Tradescantia fluminensis Vell.	Hr	PP	Dec-Jan	-	-
Tradescantia zebrina Bosse	Hr	PP	Dec-Mar	-	-
Convolvulaceae					
Ipomoea cairica (L.) Sweet	Vn	PP	Dec-May	-	-
Ipomoea obscura (L.) Ker Gawl.	Hr	PP	Dec-Feb	-	-
Costaceae					
Costus afer Ker Gawl.	Hr	PP	Dec-May	-	-
Costus barbatus Suess.	Hr	PP	Dec-May	-	-
Crassulaceae					
Kalanchoe blossfeldiana Poelln.	Hr	PP	Dec-May	-	-

Cucurbitaceae					
Cucumis melo L.	Vn	AP	Jan-Mar	N/P	Taha et al. (2019)
Cucumis sativus L.	Hr	AP	Jan-Mar	P	Primary data
Momordica charantia L.	Vn	AP	Dec-May	N/P	Thokchom et al. (2023)
Cyperaceae					
Cyperus kyllingia Endl.	Hr	PP	Dec-May	-	-
Dilleniaceae					
Tetracera scandens (L.) Merr.	Sh	PP	Dec-May	P	Primary data
Elaeocarpaceae					
Elaeocarpus angustifolius Blume	Tr	PP	Dec-Mar	-	-
Ericaceae					
Rhododendron sp.	Sh	PP	Dec-May	P	Bayram (2021)
Euphorbiaceae					
Acalypha paniculata Miq.	Hr	PP	Dec-May	-	-
Cnidoscolus aconitifolius (Mill.) I.M.Johnst.	Sh	PP	Jan-May	-	-
Codiaeum variegatum (L.) Rumph. ex A.Juss.	Sh	PP	Dec-May	-	-
Euphorbia heterophylla L.	Hr	AP	Dec-May	N/P	Akunne et al. (2016)
Euphorbia hirta L.	Hr	PP	Dec-May	N/P	Onyango et al. (2019)
Euphorbia hypericifolia L.	Hr	PP	Dec-May	-	-
Euphorbia milii Des Moul.	Sh	PP	Dec-May	N/P	Taha et al. (2019)
Euphorbia pulcherrima Willd. ex Klotzsch	Sh	PP	Dec-May	N	Thokchom et al. (2023)
Homalanthus populneus (Geiseler) Pax.	Tr	PP	Dec-May	-	-
Jatropha integerrima Jacq.	Sh	PP	Dec-May	N	Behera et al. (2017)
Macaranga rhizinoides (Blume) Müll.Arg.	Tr	PP	Dec-May	-	-
Macaranga tanarius (L.) Müll.Arg.	Tr	PP	Dec-May	-	-
Manihot esculenta Crantz	Sh	PP	Dec-May	N	Akunne et al. (2016)
Ricinus communis L.	Tr	PP	Mar-May	P	Primary data
Fabaceae					
Acacia sp.	Tr	PP	Dec-Feb	P	Primary data
Aeschynomene americana L.	Sh	PP	Mar-May	-	-
Arachis pintoi L.	Hr	PP	Dec-May	-	-
Bauhinia kockiana Korth.	Sh	PP	Dec-May	N/P	Abouu-Shaara (2015)
Bauhinia purpurea L.	Tr	PP	Dec-May	N/P	Thokchom et al. (2023)
Calliandra calothyrsus Meisn.	Sh	PP	Dec-May	P	Primary data
Cassia fistula L.	Tr	PP	Dec-May	N/P	Thokchom et al. (2023)
Caesalpinia sappan L.	Sh	PP	Dec-May	-	-
Centrosema pubescens Benth.	Vn	PP	Jan-May	P	Sopaladawan et al. (2019)
Erythrina crista-galli L.	Tr	PP	Dec-May	-	-
Gliricidia sepium (Jacq.) Walp.	Tr	PP	Feb-May	P	Gunapala et al. (2021)
Indigofera tinctoria L.	Hr	AP	Mar-May	-	
Lablab purpureus (L.) Sweet	Hr	PP	Dec-May	P	Do Nascimento et al. (2014)
Leucaena leucocephala (Lam.) de Wit	Tr	PP	Dec-Mar	P	Primary data
Mimosa pigra L.	Hr	PP	Jan-May	P	Sopaladawan et al. (2019)
Mimosa pudica L.	Hr	PP	Dec-May	P	Primary data
Senna occidentalis (L.) Link	Sh	AP	Jan-May	N/P	Akunne et al. (2016)
Senna siamea (Lam.) H.S.Irwin dan Barneby	Tr	PP	Jan-May	P	Da Silva et al. (2020)
Zapoteca portoricensis (Jacq.) H.M.Hern.	Sh	PP	Dec-May	-	-
Fagaceae					
Castanopsis argentea (Blume) A.DC.	Tr	PP	Mar	P	Primary data
Gesneriaceae					
Rhynchoglossum obliquum Blume	Hr	PP	Mar-May	-	-
Haemodoraceae					
Xiphidium caeruleum Aubl.	Hr	PP	Dec-Mar	-	-
Heliconiaceae					
Heliconia psittacorum L.f.	Hr	PP	Dec-May	N	Da Silva et al. (2020)
Heliconia rostrata Ruiz & Pav.	Hr	PP	Dec-May	N/P	Raju et al. (2013)
Iridaceae					
Gladiolus sp.	Hr	PP	Jan-Mar	-	-
Neomarica longifolia (Link & Otto) Sprague	Hr	PP	Dec-May	-	-
Lamiaceae					
Clerodendrum japonicum (Thunb.) Sweet	Sh	PP	Dec-May	-	-
Clerodendrum × *speciosum* Dombrain	Sh	PP	Dec-Feb	-	-
Clinopodium gracile (Benth.) Kuntze	Hr	PP	Dec-May	-	-
Ocimum basilicum L.	Hr	PP	Dec-May	P	Sopaladawan et al. (2019)
Phlomis sp.	Sh	PP	Dec-Feb	P	Primary data
Plectranthus verticillatus (L.f.) Druce	Hr	PP	Dec-May	N	Thokchom et al. (2023)
Rotheca serrata (L.) Steane & Mabb.	Sh	PP	Feb-May	P	Saharia (2023)

Salvia elegans Vahl	Hr	PP	Dec-May	-	-
Salvia splendens Sellow ex Schult.	Hr	PP	Dec-May	N	Thokchom et al. (2023)
Salvia xalapensis Benth.	Hr	PP	Dec-May	-	-
Lauraceae					
Cinnamomum burmannii (Nees & T.Nees) Blume.	Tr	PP	Dec-May	-	-
Persea americana Mill.	Tr	PP	Dec-May	N/P	Taha et al. (2019)
Liliaceae					
Lilium formosanum A.Wallace	Hr	PP	Jan-Feb	P	Primary data
Lythraceae					
Cuphea hyssopifolia Kunth.	Sh	PP	Dec-May	N/P	Deeksha et al. (2023)
Duabanga moluccana Blume.	Tr	PP	Mar-May	-	-
Lagerstroemia speciosa (L.) Pers.	Tr	PP	Dec-Mar	P	Khanduri (2014)
Magnoliaceae					
Magnolia champaca (L.) Baill. ex Pierre	Tr	PP	Jan-Mar	N/P	Thokchom et al. (2023)
Malvaceae					
Abelmoschus manihot (L.) Medik.	Hr	PP	Mar-May	N/P	Thokchom et al. (2023)
Ceiba pentandra (L.) Gaertn.	Tr	PP	Feb-Mar	P	Primary data
Malvaviscus arboreus Cav.	Sh	PP	Dec-May	N/P	Thokchom et al. (2023)
Sida hermaphrodita (L.) Rusby	Hr	PP	Dec-May	P	Primary data
Sida rhombifolia L.	Hr	PP	Dec-May	P	Primary data
Urena lobata L.	Hr	PP	Dec-May	N/P	Akunne et al. (2016)
Melastomataceae					
Clidemia hirta (L.) D. Don	Sh	PP	Dec-May	P	Da Silva et al. (2020)
Melastoma malabathricum L.	Sh	PP	Dec-Jan, May	-	-
Tibouchina heteromalla (D. Don.) Cogn.	Sh	PP	Dec-May	-	-
Tibouchina urvilleana (DC.) Cogn.	Sh	PP	Dec-May	-	-
Meliaceae					
Khaya anthotheca (Welw.) C.DC.	Tr	PP	Dec-Feb	P	Primary data
Melia azedarach L.	Tr	PP	Dec-May	N/P	Begum et al. (2021)
Menispermaceae					
Arcangelisia flava (L.) Merr.	Tr	PP	Apr-May	-	-
Moraceae					
Ficus hispida L.fil.	Tr	PP	Jan-Mar	P	Primary data
Ficus padana Burm.fil.	Tr	PP	Apr-May	-	-
Muntingiaceae					
Muntingia calabura L.	Tr	PP	Dec-Mar	P	Sopaladawan et al. (2019)
Musaceae					
Musa ornata Roxb.	Hr	PP	Dec-Mar	-	-
Musa × *paradisiaca* L.	Hr	PP	Dec-May	N/P	Thokchom et al. (2023)
Myrtaceae					
Eucalyptus alba Reinw. ex Blume	Tr	PP	Dec-May	P	Primary data
Eucalyptus deglupta Blume	Tr	PP	Jan-May	N/P	Abouu-Shaara (2015)
Psidium guajava L.	Tr	PP	Dec-Jan	N/P	Taha et al. (2019)
Syzygium aromaticum (L.) Merr. & Perry	Tr	PP	Dec-Mar	-	-
Syzygium aqueum (Burm.f.) Alston	Tr	PP	Dec-Jan, May	P	Primary data
Syzygium cumini (L.) Skeels	Tr	PP	Dec-May	N/P	Thokchom et al. (2023)
Syzygium jambos (L.) Alston	Tr	PP	Dec-Jan	-	-
Syzygium malaccense (L.) Merr. & L.M.Perry.	Tr	PP	Dec-May	P	Primary data
Nyctaginaceae					
Bougainvillea glabra Choisy	Sh	PP	Dec-May	P	Azmi et al. (2015)
Bougainvillea spectabilis Willd.	Sh	PP	Dec-May	-	-
Mirabilis jalapa L.	Hr	PP	Dec-Apr	-	-
Orchidaceae					
Epidendrum secundum Jacq.	Hr	PP	Dec-May	N	dos Reis et al. (2023)
Oxalidaceae					
Averrhoa bilimbi L.	Tr	PP	Dec-Feb	P	Mohamed et al. (2016)
Averrhoa carambola L.	Tr	PP	Jan-May	N	Basari et al. (2021)
Oxalis barrelieri L.	Hr	PP	Dec-May	N	Thokchom et al. (2023)
Oxalis corniculata L.	Hr	PP	Dec-May	N	Thokchom et al. (2023)
Oxalis latifolia Kunth.	Hr	PP	Dec-May	N	Thokchom et al. (2023)
Passifloraceae					
Passiflora coccinea Aubl.	Vn	PP	Dec-May	-	-
Passiflora edulis Sims	Vn	PP	Feb-May	P	Primary data
Pedaliaceae					
Sesamum indicum L.	Sh	PP	Feb-May	P	Primary data
Phyllantaceae					
Phyllanthus borneensis Müll.Arg.	Tr	PP	May	-	-

Phytolaccaceae					
Phytolacca icosandra L.	Sh	PP	Dec-May	P	Araujo-Mondragón and Redonda-Martínez (2019)
Rivina humilis L.	Hr	PP	Dec-May	-	-
Pinaceae					
Pinus merkusii Jungh. & de Vriese	Tr	PP	Dec-Jan	P	Primary data
Piperaceae					
Piper aduncum L.	Tr	PP	Dec-May	P	Bosco and da Luz (2018)
Pittosporaceae					
Pittosporum moluccanum (Lam.) Miq.	Sh	PP	Dec-Feb	-	-
Plantaginaceae					
Plantago major L.	Hr	PP	Dec-May	-	-
Plumbaginaceae					
Plumbago auriculata Lam.	Sh	PP	Dec-Mar	-	-
Polygalaceae					
Polygala paniculata L.	Hr	PP	Dec-May	-	-
Polygonaceae					
Persicaria maculosa Gray	Hr	AP	Dec-May	P	Bouba et al. (2020)
Portulacaceae					
Portulaca grandiflora Hook.	Hr	AP	Dec-May	N/P	Begum et al. (2021)
Portulaca oleracea L.	Hr	PP	Dec-May	P	Sopaladawan et al. (2019)
Primulaceae					
Ardisia elliptica Thunb.	Sh	PP	Dec-May	N	Yong et al. (2019)
Rhamnaceae					
Maesopsis eminii Engl.	Tr	PP	Dec-May	-	-
Rosaceae					
Eriobotrya japonica (Thunb.) Lindl.	Tr	PP	Dec-Jan	P	Rasoloarijao et al. (2018)
Fragaria x *ananassa* (Weston) Duchesne	Hr	PP	Dec-May	N/P	Thokchom et al. (2023)
Rosa sp.	Sh	PP	Dec-May	N/P	Thokchom et al. (2023)
Rubus rosifolius Sm.	Hr	PP	Dec-May	P	Rasoloarijao et al. (2018)
Rubiaceae					
Hamelia patens Jacq.	Sh	PP	Dec-May	N/P	Kumari and Kumar (2019)
Ixora sp.	Sh	PP	Dec-May	N/P	Thokchom et al. (2023)
Mussaenda frondosa L.	Sh	PP	Jan-Mar	-	-
Richardia brasiliensis Gomes	Hr	AP	Dec-May	N	Shackleton et al. (2016)
Richardia scabra L.	Hr	AP	Dec-Feb	P	Primary data
Rutaceae					
Citrus sinensis (Mill.) Pers.	Sh	PP	Dec-May	P	Primary data
Sapotaceae					
Palaquium obovatum (Griff.) Engl.	Tr	PP	May	-	-
Solanaceae					
Brugmansia arborea (L.) Sweet	Tr	PP	Dec-May	-	-
Brugmansia candida Pers.	Tr	PP	Dec-May	-	-
Brunfelsia uniflora (Pohl) D.Don	Sh	PP	Dec-Mar	-	-
Capsicum frutescens L.	Hr	PP	Dec-May	P	Primary data
Cestrum elegans (Brongn. ex Neumann) Schltdl.	Sh	PP	Dec-May	-	-
Datura metel L.	Sh	AP	Dec-Jan	P	Primary data
Solandra maxima (Moc. & Sessé sx Dunal) P.S.Green	Vn	PP	Dec-May	-	-
Solanum americanum Mill.	Hr	PP	Dec-May	P	Do Nascimento et al. (2014)
Solanum diphyllum L.	Hr	PP	Dec-May	-	-
Solanum erianthum D.Don	Sh	PP	Dec-May	-	-
Solanum lycopersicum L.	Vn	AP	Dec-May	P	Primary data
Solanum macranthum Dunal	Tr	PP	Dec-May	-	-
Solanum torvum Sw.	Sh	PP	Dec-May	N/P	Akunne et al. (2016)
Theaceae					
Camellia sinensis (L.) Kuntze	Sh	PP	Dec-Feb	P	Primary data
Schima wallichii Choisy	Tr	PP	Dec-May	P	Primary data
Urticaceae					
Debregeasia longifolia (Burm.fil.) Wedd.	Hr	PP	Mar-May	-	-
Dendrocnide stimulans (L.f.) Chew	Tr	PP	Dec-Mar	-	-
Oreocnide rubescens (Blume) Miq.	Tr	PP	Feb-Mar	-	-
Pilea cadierei Gagnep. & Guillaumin	Hr	PP	Feb-May	-	-
Pilea pumila (L.) A. Gray	Sh	PP	Dec-May	-	-
Villebrunea rubescens (Blume) Blume	Sh	PP	Dec-May	P	Primary data
Verbenaceae					
Duranta erecta L.	Sh	AP	Dec-May	N/P	Taha et al. (2019)
Lantana camara L.	Hr	PP	Dec-May	N/P	Akunne et al. (2016)
Stachytarpheta jamaicensis (L.) Vahl	Hr	PP	Dec-May	N/P	Akunne et al. (2016)

Note: Habit: Habitus; Hr: Herbaceous; Tr: Tree, Sh: Shrub; Vn: Vine; LC: Life Cycle; PP: Perennial Plant; AP: Annual Plant; BP: Biennial Plant; RO: Resource Offered; P: Pollen; N: Nectar

Table 2. List of polliniferous plants with their pollen characteristics

Family	Species	Pollen unit	Ornamentation	Size (µm)	Category
Anacardiaceae	*Mangifera indica* L.	Monad	Reticulate	12.5	Small
Amaranthaceae	*Alternanthera sessilis* (L.) R.Br. ex DC.	Monad	Reticulate	26	Medium
Amaranthaceae	*Amaranthus spinosus* L.	Monad	Reticulate	26	Medium
Apocynaceae	*Alstonia scholaris* (L.) R.Br.	Monad	Psilate	23	Small
Arecaceae	*Arenga pinnata* (Wurmb) Merr.	Monad	Echinate	30	Medium
Asteraceae	*Ageratum conyzoides* (L.) L.	Monad	Echinate	26	Medium
Asteraceae	*Bidens pilosa* L.	Monad	Echinate	26	Medium
Asteraceae	*Tithonia diversifolia* (Hemsl.) A.Gray	Monad	Echinate	12.5	Small
Bignoniaceae	*Kigelia africana* (Lam.) Benth.	Monad	Reticulate	50	Large
Bignoniaceae	*Spathodea campanulata* P.Beauv	Monad	Reticulate	37.5	Medium
Brassicaceae	*Brassica oleracea* L.	Monad	Reticulate	41-50	Medium
Cannabaceae	*Trema orientalis* (L.) Blume	Monad	Psilate	23	Small
Cucurbitaceae	*Cucumis sativus* L.	Monad	Reticulate	26-50	Medium
Dilleniaceae	*Tetracera scandens* (L.) Merr.	Monad	Reticulate, Scabrate	16	Small
Euphorbiaceae	*Ricinus communis* L.	Monad	Reticulate	50	Large
Fabaceae	*Acacia* sp.	Polyad	Psilate	48	Medium
Fabaceae	*Calliandra calothyrsus* Meisn.	Polyad	Verrucate	>100	Very large
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit	Monad	Perforate	68	Large
Fabaceae	*Mimosa pudica* L.	Tetrad	Psilate	10-15	Small
Fagaceae	*Castanopsis argentea* (Blume) A.DC.	Monad	Psilate	40	Medium
Lamiaceae	*Phlomis* sp.	Monad	Reticulate	28	Medium
Liliaceae	*Lilium formosanum* A.Wallace	Monad	Reticulate	37.5	Medium
Malvaceae	*Ceiba pentandra* (L.) Gaertn.	Monad	Reticulate	50	Large
Malvaceae	*Sida hermaphrodita* (L.) Rusby	Monad	Echinate	62.5	Large
Malvaceae	*Sida rhombifolia* L.	Monad	Echinate	62.5	Large
Meliaceae	*Khaya anthotheca* (Welw.) C.DC.	Monad	Psilate	80	Large
Moraceae	*Ficus hispida* L.fil.	Monad	Psilate	15	Small
Myrtaceae	*Eucalyptus alba* Reinw. ex Blume	Monad	Psilate	15	Small
Myrtaceae	*Syzygium aqueum* (Burm.f.) Alston	Monad	Scabrate	12.5	Small
Myrtaceae	*Syzygium malaccense* (L.) Merr. & L.M.Perry.	Monad	Psilate	20	Small
Passifloraceae	*Passiflora edulis* Sims	Monad	Reticulate	75	Large
Pedaliaceae	*Sesamum indicum* L.	Monad	Verrucate	69	Large
Pinaceae	*Pinus merkusii* Jungh. & de Vriese	Monad	Reticulate	62.5	Large
Rubiaceae	*Richardia scabra* L.	Monad	Reticulate	62.5	Large
Rutaceae	*Citrus sinensis* (Mill.) Pers.	Monad	Reticulate	26	Medium
Solanaceae	*Capsicum frutescens* L.	Monad	Verrucate	26-30	Medium
Solanaceae	*Datura metel* L.	Monad	Striate	50	Large
Solanaceae	*Solanum lycopersicum* L.	Monad	Psilate	16-20	Small
Theaceae	*Camellia sinensis* (L.) Kuntze	Monad	Gemmate	62.5	Large
Theaceae	*Schima wallichii* Choisy	Monad	Striate	40	Medium
Urticaceae	*Villebrunea rubescens* (Blume) Blume	Monad	Reticulate	9	Very small

Herbaceous plants also dominated the flowering plants discovered throughout the research period regarding vegetative habitus. This condition provides honey bees an advantage as well. Although perennial plants with tree habitus are good sources of nectar and honey bees have the ability to forage in the upper canopy, Onyango et al. (2019) claim that herbs and shrubs are better food sources for bees. Due to their rapid growth and flourishing, easy seed collection, and ability to be replanted for the following growing season, these herbaceous plants that thrive as weeds in farmed fields, abandoned open spaces, and wastelands and as ornamentals are an essential source of feed for bees. In addition to the survival, quantity, and distribution of honeybees, a major determining factor is the availability of sufficient year-round and annual supplies of nectar and pollen (Kiffle et al. 2014).

Honeybees completely depend on flowering plants for their food needs (Hosamani et al. 2018). Therefore, to attract different types of pollinators, each flower species produces different amounts of nectar (Basari et al. 2021). Previous research explains that nectar is a sweet liquid from flowers and additional flower sources and is the main ingredient for making honey, while pollen is a high-protein food source for bees. Plants that produce both compounds are known as 'bee pastures,' which are areas with diverse flowering plants that provide abundant nectar and pollen for bees. If nectar production is abundant from several plants of a particular species, this is called a 'period of great honey flow.' On the other hand, collecting a small amount of nectar is known as the 'period of small honey flow,' while the 'period of scarcity' is a period with no honey flow (Hosamani et al. 2018). The present study revealed that most of the Ir. H. Djuanda flowering plants were polliniferous (30.52%) instead of nectariferous (10.04%), and 18.47% of species produced both floral resources (Table 1). Djuanda GFP site managers must ensure that the number of "major honey flow period" species in the future is higher than the status quo to increase honey production.

Furthermore, since honeybees rely on nectar and pollen, their development and population depend entirely on plant availability and flowering season (Tahir et al. 2021). The abundance of bee plants and the frequency of honey flow, or scarcities, had to be regularly monitored (Bhattarai et al. 2023). This required beekeepers to know the timing of honey flows or scarcities and the blooming period of melliferous plants. Thus, additional research must be done to determine the blooming time of melliferous plants in the sampled study sites for the entire year and relate it with the seasonal conditions for each month.

Pollen identification in this study revealed that the polliniferous plant family with the most species was Fabaceae, followed by Asteraceae and other families. Research in Brazil investigating the pollen composition of 34 honey samples identified 114 different pollens spread across 43 families. Fabaceae pollen types are the most varied, with up to 20 varieties (Bosco and da Luz 2018). Another research in Kenya found that Fabaceae was the most frequently visited (Onyango et al. 2019). Forman et al. (2003) confirmed similar findings, stating that beans are the most frequently visited plant due to their lengthy and beautiful flowering cycle. Decourtye et al. (2010) reported Fabaceae as food for bees. Although there are some observable benefits, the slow growth of certain legumes may be a limiting problem under certain conditions due to the lack of flowering in the first year.

However, Asteraceae came out on top regarding the quantity of pollen measured for this research. Ageratum conyzoides, a herbaceous species belonging to Asteraceae family, has the most pollen among the samples we collected from Batu Garok, Kandang Rusa, and Maribaya. Herbal plants are very important for bees because their growth and flowering periods are often shorter than trees, according to Rismayanti et al. (2015). The majority of species in the Asteraceae family are herbaceous. Every year or at any moment, herbaceous plants can bloom. The Ageratum conyzoides plant's tiny pollen makes it ideal for honey bees to consume as food (Priambudi et al. 2021).

Honeybees are very important to the ecosystem because they pollinate various plants. This research presents 147 types of plants as mellifera plants in the sampled research locations. Based on information on the blooming period, there are more than 100 species of melliferous plants every month. However, from the discussion above, it cannot be concluded whether the research locations sampled can be considered appropriate areas to start beekeeping to improve farmers' livelihoods. However, the findings of this research can guide beekeepers and farmers in selecting suitable locations and planning their activities to maximize the benefits of honeybee pollination. This research only covers a half-year period of the flower blooming calendar. Seasonal fluctuations in nectar availability create a “hunger gap” when nectar supply cannot meet pollinator demand. Maintaining a variety of semi-natural habitats with complementary flowering periods can help ensure a continuous supply of nectar throughout the year (Timberlake et al. 2019). Honeybees may use alternative sugar sources like fruit juice during nectar scarcity. Although fruit juice has a lower sugar concentration, it can still provide necessary energy and help maintain the colony sugar-water balance (Shackleton et al. 2016). Some plants produce nectarless flowers that emit volatile compounds to attract pollinators, potentially compensating for the shortage of nectar and maintaining pollination even during resource scarcity (Guimarães et al. 2018). Therefore, further study of the blooming calendar for the whole year is essential, as is sharing knowledge with farmers about the availability of melliferous plants in certain months and giving them the authority to make decisions in sustainable beekeeping.

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